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Homogeneous Macroclimatic Zones of the Lake States

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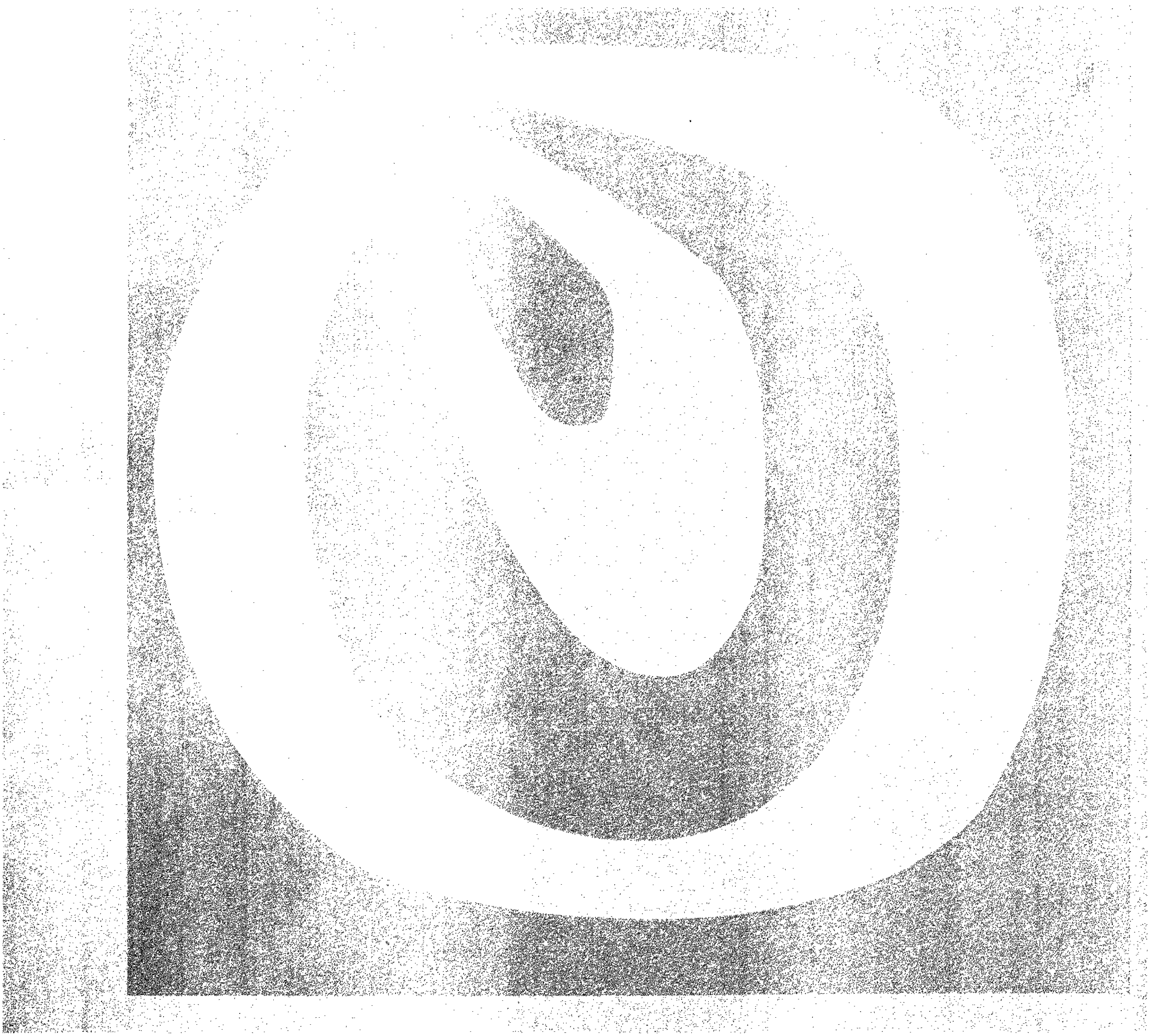

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North Central Forest Experiment Station
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HOMOGENEOUS MACROCLIMATIC ZONES OF THE LAKE STATES

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The prevailing weather conditions of a region, its climate, influences the development of the soil and the vegetation in that region. Many attempts have been made to classify climates in order to explain the distribution of forests and other vegetation types (Spurr and Barnes 1980). Each classification has shown some interesting delineations, but none has been completely satisfactory (Daniel *et al.* 1979, Spurr and Barnes 1980).

Another reason to classify climate is to decompose the abundant natural variations of forest ecosystems. The process of classifying climate produces homologous units having characteristic features of their own and requiring distinct treatment (Zon 1908, Miller and Auclair 1974). These homogeneous climatic classes, called homoclimes, help us organize our knowledge, bring out and understand relations among the homoclimes, and establish classes useful for practical, applied purposes. Identification of homoclimes reduces within-class variation to help in predicting future behavior, in estimating productivity, and in extending and extrapolating research results.

Homoclimes can be used to statistically remove the effect of macroclimate from the dependent variables in experimental research data. Yield tables should be prepared by homologous units, based within known homoclimes, and these same units should be the basic units of experimental forestry work (Zon 1908). Homoclimatic zones may serve as a comprehensive frame of reference for more specific sets of observations such as intensive, site-specific studies (Miller and Auclair 1974). Homoclimes are likely to identify regions where tree growth, regeneration, stand structure, and composition are similar (Miller and Auclair 1974). Wilde (1976) stresses that the relations between productive capacity of soils and the growth of forest stands undergo significant, even radical, modifications in going from one climatic region to another. Broad, climate-negligent generalizations should be regarded with extreme suspicion. Loucks (1962) warns that bio-environmental investigations and relations should be restricted to "small regions of essentially uniform climate". Extrapolation of such relations outside the climatic zone of the study can seldom be justified (Loucks 1962).

Homoclimes have not been defined for the Lake States—Michigan, Minnesota, and Wisconsin. In Canada, homoclimes have been defined for the Maritime Provinces (Putnam 1940), insular Newfoundland (Nicholson and Bryant 1972), northern Ontario (Chapman 1953), and southern Ontario (Putnam and Chapman 1938). Climatic descriptions in the eastern United States have been either too broad to be of much utility (Kendall 1935) or have failed to synthesize the important climatic variables into homoclimatic zones (Borchert 1950, Lull 1968, Nelson and Zillgitt 1969, Merz 1978).

This paper describes and summarizes the macroclimate of the Lake States by defining and mapping homoclimatic zones.

METHODS

The various elements of climate affect forest vegetation through the three most essential conditions of plant life: heat, light, and moisture (Putnam and Chapman 1938, Zon 1941). I selected variables estimating these three influences from generally available meteorological records (Appendix A). Several considerations were used to select variables. Summary data for the months of January, April, July, and October were used to estimate seasonal variation. The variables selected had to be available for all three States. Finally, the variables chosen had to express the maximum amount of variation across the region so as to increase the information content of the data base. For example, mean monthly possible sunshine in January was selected as a cloudiness index because neither July nor the annual mean monthly figures showed much regional variation.

A data base was compiled for Michigan, Wisconsin, and Minnesota using readings from the National Oceanic and Atmospheric Administration (NOAA) network of climatological data stations and published isopleth diagrams (isograms) (fig. 1, table 1). Whenever possible, published isogram maps were used to extract the value of each variable at each grid location. Where published isograms were not available, data for the latest available 30-year normals were used to generate isograms. Unattenuated potential solar radiation values were computed using program RAD (Hill 1976).

A systematic grid system with cells measuring 15 by 15 miles was superimposed on a county level map of the Lake States (USDA 1952). Data from published isograms or isograms constructed from NOAA summary reports were related to this grid system and identified by reference to the nearest grid coordinate.

The resultant data base had 846 observations, each corresponding to a grid intersection, and 53 primary variables. Thirty of the 53 variables were temperature related, 14 were precipitation related, and 9 were radiation related. A principal components analysis was executed for the 30 temperature related variables, the 14 precipitation related variables, and the 9 radiation related variables separately using the FACTOR procedure in SAS79 (Helwig and Council 1979). This analysis yielded two temperature components, accounting for 86 percent of the variation; three precipitation components, accounting for 81 percent of the variation; and two radiation components, accounting for 91 percent of the variation. (A detailed description and a worked example of principal component analysis are given in Appendix D.)

Table 1.—*Summary of the locations of the NOAA recording Stations in the Lake States*

State	Urban	Rural[1]	Airports
Michigan	319	47	11
Minnesota	118	2	3
Wisconsin	240	15	2
Total	677	64	16

[1]More than 3 miles from a post office.

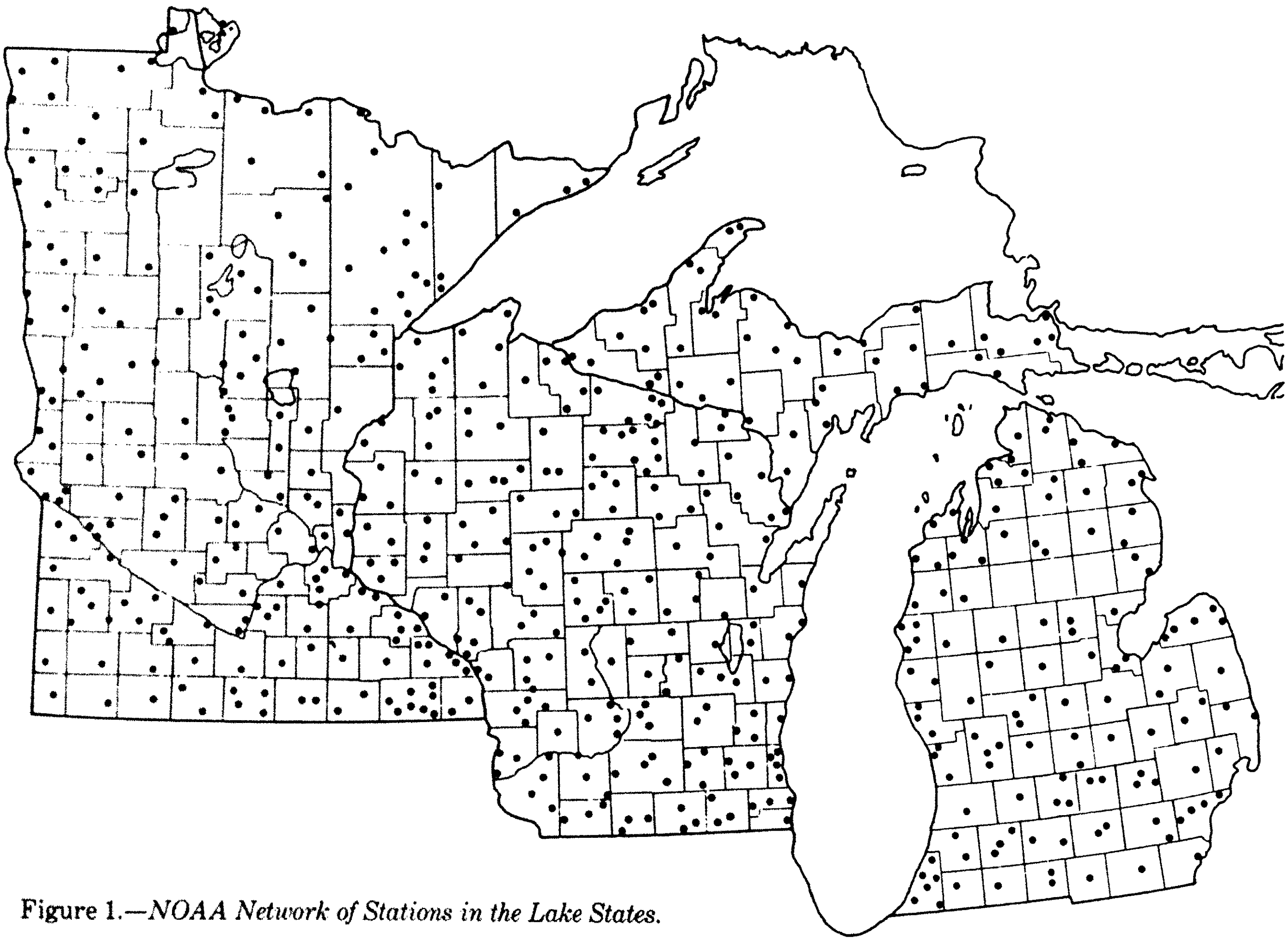

Figure 1.—*NOAA Network of Stations in the Lake States.*

This new data set, consisting of 846 observations and 7 components, was subjected to the SAS79 procedure FASTCLUS (SAS 1981). FASTCLUS is designed for clustering of large data sets—i.e., more than about 200 observations. Several different clustering algorithms should be employed on the same data set to reveal various facets of the structure (Anderberg 1973). This was not possible because FASTCLUS was the only available computer pro ram that could cluster 846 observations at an affordable cost.

The objective of cluster analysis is to discover a category structure that fits the observational units when little or no a-priori knowledge is available about the structure (Anderberg 1973). The results of cluster analysis may be treated as summary statistics of a *descriptive* nature, much like the mean and variance (Anderberg 1973). The clusters describe which observations seem to be associated and which seem to be foreign to each other. Cluster analysis is not involved with hypothesis testing.

The choice of the number of clusters to select is difficult (Anderberg 1973). After a series of trials, I judged that 20 clusters produced a reasonable set of homoclimes. It must be stressed that although these 20 homoclimes are not unique, I feel reasonably comfortable that the data set supports 20 plus or minus 3 to 4 clusters. When the 846 observations were mapped, only 7 intruded in a homoclime not their own. This is a powerful corroboration of the essential trustworthiness of the 20 final clusters given the data used. When more than 20 clusters were computed, numerous very small clusters resulted and the majority of the large clusters were unchanged. The accuracy of the data set did not seem to support maintaining numerous clusters of small areal extent. Their small size would limit their utility and the danger of spurious clusters seemed too high. Conversely, computing less than 20 clusters did not take full advantage of the refinement of which the data set was capable.

A printout of the raw data set, 846 observations by 53 variables, is available from the author upon request.

RESULTS

Interpreting the Principal Components

An analysis of the factor pattern matrices yields the following interpretation of the meaning of each component (table 2). The components are labeled as follows: LS for Lake States; T,P, or R for temperature, precipitation, or radiation; and a number that indicates the percentage of the total variation accounted for by that component.

The variables with high positive factor loadings (see Appendix D for explanation) in component LST79 are indicated by a "+" and those with high negative loadings are indicated by a "–". The component LST79 will have a large score (see Appendix D for explanation) if the variables with a high positive factor loading are large in magnitude and if the variables with high negative loadings are small in magnitude. Therefore, LST79 is the high/low temperature component because large values in the positive loading group of variables and small values in the negative loading group of variables correspond to a high factor score, which corresponds to hot climatic conditions.

A high factor score on component LST07 represents extreme temperatures—hot summers and cold winters. A low factor score represents the reverse—cool summers and warm winters. This factor represents only 7 percent of the total variation due to temperature. The high negative factor loading on average minimum and average January temperature results from the raw data values being negative. Therefore, large negative values in the raw data, corresponding to cold conditions, translate into a large positive contribution to the component because the double negatives cancel out each other.

Large values of component LSP48 characterize a wet winter and fall with an abundance of snow while low values represent the reverse. Large values of the second precipitation component, (LSP21, signify heavy snowfall in early and late winter. Although total precipitation in April is average or low, it is all snow. Low values signify the reverse, that is, low snowfall amounts concentrated in the middle of the winter. High values of the last precipitation component, LSP12, characterize a zone with high annual precipitation that comes predominantly in the summer.

High values of component LSR63 signify zones with high solar radiation and high evaporation; low values signify the reverse. Finally, high values of component LSR29 signify zones with many clear days throughout the year; low values characterize zones with abundant cloudiness.

Interpretation of the Homoclimes

Figure 2 presents the homoclimatic regions of the Lake States, numbered 1 through 20. To relate each of the 20 homoclimes to the 7 components, a profile plot was prepared (table 3). A profile plot is a graphic aid useful for displaying the relative position of objects across some scale of measure. For example, in table 3 homoclimes are plotted in relation to their median scores on the seven principal components. It is evident that homoclimes 13, 10, 5 and 20 represent the cold temperature extreme and homoclimes 17, 1, 16, and 19 represent the warm temperature extreme (LST79).

Homoclime 10 is singled out by LST07 as having a hot summer and a cold winter—a high temperature extreme between the seasons. Homoclimes 11, 12, 6, and 2 in particular, as well as 7, 1, 19, 16, 17, and 20 show up as having the least extremes between the seasons. For example, in homoclime 10 the difference between the average maximum temperature in July and the average minimum temperature in January is 87°F while in homoclime 11 this difference is only 68°F (Appendix B). (Appendix B contains a list of the median value by homoclime, in raw data units, of each variable used in the analysis.)

The relation of homoclimes on LSP48 identifies homoclime 12 as having a snowy fall and winter while homoclimes 10, 3, 8, 9, and 15 get little snow. The average total snowfall in January in homoclime 12 is 35 inches while in homoclime 10 it is 8 inches. Homoclimes 12 and 20 receive large amounts of snow in early and late winter (LSP21) while homoclimes 19, 16, 1, and 17 get their snowfall primarily in mid-winter. Homoclime 18 experiences high amounts of annual precipitation, most of which comes in the

Table 2.—*The factor pattern matrix from the principal components analysis for the Lake States*

TEMPERATURES

Variable	Variable codes[1]	Factor code	
		LST79[2]	LST07[2]
Avg. temp. Jan.	T1	0.9 +[3]	-0.3 -
Avg. temp. Apr.	T2	0.6 +	0.1
Avg. temp. July	T3	0.8 +	0.4 +
Avg. temp. Oct.	T4	0.9 +	0.1
Avg. min. temp. Jan.	T5	0.7 +	-0.4 -
Avg. min. temp. April	T6	0.9 +	0.1
Avg. min. temp. July	T7	0.8 +	0.3 +
Avg. min. temp. Oct.	T8	0.9 +	-0.1
Avg. max. temp. Jan.	T9	0.8 +	-0.3 -
Avg. max. temp. April	T10	0.8 +	0.3 +
Avg. max. temp. July	T11	0.7 +	0.4 +
Avg. max. temp. Oct.	T12	0.9 +	0.1
No. of days temp. ⩾90° F in July	T15	-0.8 -	0.3 +
No. of days temp. ⩽32° F in April	T18	-0.9 -	0.1
No. of days temp. ⩽32° F in Oct.	T20	-0.8 -	0
Days since Jan. 1 to last day of 32°F or lower in spring	T22	0.9 +	0
Days since Jan. 1 to first day of 32°F or lower in fall	T23	-0.8 -	0
Heating degree days, 65°F Base	T24	0.9 +	0
Runs of ⩾ 5 days with max. temp. > 30°F Jan. 24-30	T25	-0.9 -	0
Runs of ⩾ 5 days with min. temp. ⩽ 50°F Sept. 20-26	T36	-0.4	0.6 +
Runs of ⩾ 5 days with max. temp. > 30°F March 1-7	T26	0.9 +	0
Runs of ⩾ 5 days with max. temp. > 30°F Dec. 27-Jan. 2	T27	0.9 +	0
Runs of ⩾ 5 days with max. temp. > 50°F March 22-28	T28	0.9 +	0
Runs of ⩾ 5 days with max. temp. > 50°F Nov. 8-14	T29	0.9 +	0
Runs of ⩾ 5 days with max. temp. > 90°F July 19-25	T30	-0.9 -	0
Runs of ⩾ 5 days with min. temp.			
⩽ 0°F Jan. 10-16	T31	-0.8 -	0.4 +
⩽ 0°F Feb. 21-27	T32	-0.9 -	0
Runs of ⩾5 days with min. temp. ⩽ 40°F April 26-May 2	T33	-0.9 -	0
Runs of ⩾ 5 days with min. temp. ⩽ 40°F Oct. 4-10	T34	-0.9 -	0.1
Runs of ⩾ 5 days with min. temp. ⩽ 50°F May 24-30	T35	-0.9 -	0

(Continued on next page)

(Table 2 continued)

PRECIPITATION				
Variable	**Variable codes**[1]	**Factor code**		
		LSP48[2]	**LSP21**[2]	**LSP12**[2]
Avg. annual total precipitation in inches	P1	0.6 +	-0.2	0.4 +
Avg. annual total number of days		0.8 +	0	0
precipitation > 0.1″	P2	0.8 +	-0.2	0
Avg. total precipitation in Jan.	P3	0.6 +	-0.6 -	0.1
Avg. total precipitation in April	P4	-0.1	0.1	0.8
Avg. total precipitation in July	P5	0.8 +	-0.2	0.1
Avg. total precipitation in Oct.	P6			
Avg. total number of days with precipitation > 0.1″ in Jan.	P7	0.8 +	-0.1	-0.2
Avg. total number of days with precipitation ⩾ 0.1″ percent in April	P8	0.7 +	-0.5 -	0
Avg. total number of days with precipitation ⩾ 0.1″ percent in July	P9	0	0.3	0.7 +
Avg. total number of days with precipitation ⩾ 0.1″ percent in Oct.	P10	0.8 +	0	0.1
Avg. annual total snowfall in inches	P11	0.6 +	0.6 +	0
Avg. total snowfall in April	P13	0.1	0.8 +	0
Avg. total snowfall in Nov.	P14	0.4	0.7 +	0

SOLAR RADIATION			
Variable	**Variable codes**[1]	**Factor code**	
		LSR63[2]	**LSR29**[2]
Potential solar radiation Jan.	R2	0.9 +	-0.2
Potential solar radiation April	R3	0.9 +	-0.2
Potential solar radiation July	R4	0.9 +	-0.2
Potential solar radiation Oct.	R5	0.9 +	-0.2
Mean monthly percent possible sunshine Jan.	R6	0	0.8 +
Potential solar radiation - annual	R11	0.9 +	-0.2
Mean annual total hours of sunshine,	R8	0.4	0.7 +
Mean annual number of clear days, sunrise to sunset	R9	0.3	0.8 +
Mean annual pan evaporation (inches)	R10	0.7 +	0.4

[1]Component Code Legend: LS = Lake State, T, P, R = Temperature, Precipitation, Radiation 79, 07, 48, 21, 12, 63, 29 = Proportion of variation accounted for by that component.

[2]Factor Code Legend: LS = Lake States; T = temperature; P = precipitation; and R = solar radiation; and the numbers = percent of variation accounted for.

[3]Variables with a + or -beside the factor pattern value are influential (positively or negatively) in determining component measuring.

summer (LSP12), whereas homoclime 12 experiences high annual precipitation, most of which comes in the winter. Homoclimes 18 and 12 both receive more precipitation than the regional median, but 18 receives 13 percent of the annual total precipitation in July, the highest in the region, whereas homoclime 12 receives only 8 percent of its annual total precipitation in July, sharing a regional low with homoclimes 11, 6, and 2. Homoclime 18 stands out as being very different in this respect than any other homoclime in the region.

Total annual potential solar radiation and pan evaporation are high in homoclimes 16, 19, 8, and 1 and low in homoclimes 13 and 10 (LSR63). Homoclime 8 is dramatically isolated as having the largest number of clear days in the year (LSR29) while homoclime 7 experiences the most cloudiness annually. Homoclime 7 receives only 25 percent of the mean annual possible sunshine while homoclime 8 receives 55 percent. To further emphasize the difference, homoclime 7 has less potential solar radiation incoming than does homoclime 8.

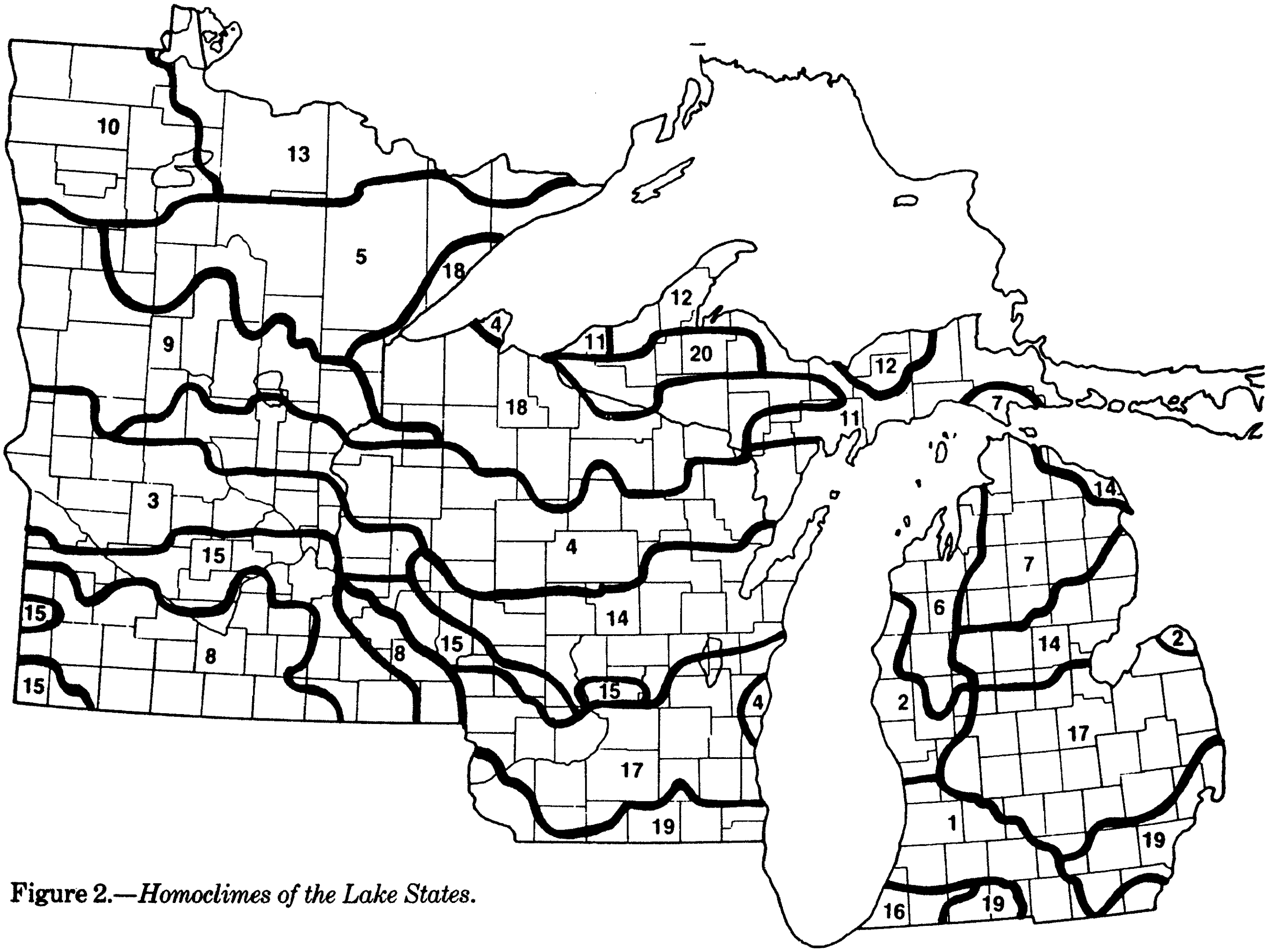

Figure 2.—*Homoclimes of the Lake States.*

Appendix C contains a detailed profile of each homoclime as it is related in multidimensional space to all other homoclimes. The profile plots in Appendix C place similar homoclimes in adjacent positions and dissimilar homoclimes in distant positions based upon euclidean distances obtained from the cluster analysis. Furthermore, for each homoclime some key explanatory variables are presented along with summary statistics for them. These homoclime summaries are intended to provide a quick overview of the salient features of the particular homoclime in question.

SUMMARY

To collate and summarize the characteristics of the climate of the Lake States region, 20 homoclimes have been defined and mapped. The homoclimes have been analyzed, quantitatively described, and compared with each other. The major patterns of temperature, precipitation, and radiation have been described.

It should be understood that in a study of this kind the normal or average characteristics are used. In attempts to relate vegetative composition or dynamics to these homoclimes, the variations of the climatic factors around their normal values must be taken into account. Additional variation will also be introduced by the differential influence of specific sites on the homoclimatic averages. Microclimates within each homoclime should be investigated, stratitified, and related quantitatively to the homoclimatic averages.

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Table 3.—*Profile plot of the seven principal components (LST9, LST07, LSP48, LSP21, LSP12, LSR63, LSR24) based on median scores for each homoclime (1-20) on each component*

Principal component	Minimum value	Homoclimes relative to each other				Maximum value
LST79[1]	-31	13. .10.05.20	18.12.11.04.07 .09. . .	03.14.06.15.02 08	17. . .01.16 . . .19.	65
LST07	-8	11.12.07.01.16[2] .06. .19.17 .02. . .20	.18.04. . .14.	. .05.13.08 . . .15.03 09	. . . .10	3
LSP48	-9	10.03.08.15. . .09.	05.04.14.18.19 13. . .17.	. . .07.01 . . . .11 02	06.16. . .12 .20.	19
LSP21	-5	19.16.01. .02 . .17. .14	.15.04.06.07 .08.03.09.18	10.05.11. . . .13. .	. .20. .12	10
LSP12	-3	12. .06.02.10 . . .11.07	03.09.15.14.16 01. .08.17.	13.05.20.04. .19. . .	. .18.	3
LSR63	-10	13.10. .12. . . .05. . . .11. . . .20.	18. .09.07.04	.06.14.02. .03.	15. .08.19.16 17. .01.	10
LSR29	-5	07. .06.11.20 . .02.12.01 16	19.18. .17.04 . . . .14	05.13. .09.15 . . . .03 10	. . .08.	5

[1] Component Code Legend: LS = Lake State, T, P, R = Temperature, Precip Radiation 79, 07, 48, 21, 12, 63, 29 = Proportion of variation accounted for by component.

[2] Homoclimes 16, 17, and 20 hold the same relative position across component LST07.

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Appendix A.—Listing of variables used and their sources

TEMPERATURE

Variable	Variable code	Reference MI	Reference MN	Reference WI
Avg. temp. Jan.	T1	19/B1/M[1]	4/8/M	35/6-14/R
Avg. temp. Apr.	T2	19/B4/M	4/9/M	35/6-14/R
Avg. temp. July	T3	19/B7/M	4/10/M	35/6-14/R
Avg. temp. Oct.	T4	19/B10/M	4/4/M	35/6-14/R
Avg. min. temp. Jan.	T5	22/E1/M	4/12/M	35/6-14/R
Avg. min. temp. April	T6	22/E4/M	4/16/M	35/6-14/R
Avg. min. temp. July	T7	22/E7/M	4/17/M	35/6-14/R
Avg. min. temp. Oct.	T8	22/E10/M	4/19/M	35/6-14/R
Avg. max. temp. Jan.	T9	21/D1/M	4/12/M	35/6-14/R
Avg. max. temp. April	T10	21/D4/M	4/15/M	35/6-14/R
Avg. max. temp. July	T11	21/D7/M	4/17/M	35/6-14/R
Avg. max. temp. Oct.	T12	21/D10/M	4/18/M	35/6-14/R
No. of days temp. ≥ 90°F in July	T15	33/*/R	34/*/R	35/6-14/R
No. of days temp. ≤ 32°F in April	T18	33/*/R	34/*/R	35/6-14/R
No. of days temp. ≤ 32°F in Oct.	T20	33/*/R	34/*/R	35/6-14/R
Days since Jan. 1 to last day of 32°F or lower in spring	T22	25/5/R	2/14/M	37/6/M
Days since Jan. 1 to first day of 32°F or lower in fall	T23	5/5/R	2/15/M	37/7/M
Heating degree days, 65°F Base	T24	24/F13/M	6/68/M	6/68/M
Run of > 5 days with max. temp. > 30°F Jan. 24-30	T25	12/8/M	10/8/M	10/8/M
Run of ≥ 5 days with min. temp. ≤ 50°F Sept. 20-26	T36	10/68/M	10/71/M	10/68/M
Runs of ≥ 5 days with max. temp. < 30°F March 1-17	T26	10/9/M	10/9/M	10/9/M
Runs of ≥ 5 days with max. temp. > 30°F Dec. 27-Jan. 2	T27	10/10/M	10/10/M	10/10/M
Runs of ≥ 5 days with max. temp. > 50°F March 22-28	T28	10/29/M	10/29/M	10/29/M
Runs of ≥ 5 days with max. temp. > 50°F Nov. 8-14	T29	10/31/M	10/31/M	10/31/M
Runs of ≥ 5 days with max. temp. > 90°F July 19-25				
Runs of ≥ 5 days with min. temp. < 0°F Jan. 10-16	T31	10/44/M	10/44/M	10/44/M
Runs of ≥ 5 days with max. temp. ≤ 0°F Feb. 21-27	T32	10/45/M	10/45/M	10/45/M
Runs of ≥ 5 days with min. temp. ≤ 40°F April 26-May 2	T33	10/57/M	10/57/M	10/57/M
Runs of ≥ 5 days with min. temp. ≤ 40°F Oct. 4-10	T34	10/58/M	10/58/M	10/58/M
Run of ≥ 5 days with min. temp. ≤ 50°F May 24-30	T35	10/67/M	10/67/M	10/67/M
PRECIPITATION				
Avg annual total precipitation in inches	P1	18/A13/M	5/12/M	49/6-14/R
Avg. annual total number of days precipitation > 0.1"	P2	23/L13/M	6/71/M	49/6-14/R
Avg. total precipitation in Jan. in inches	P3	18/A1/M	5/16/M	49/6-14/R
Avg. total precipitation in April in inches	P4	18/A4/M	5/16/M	49/6-14/R
Avg. total precipitation in July in inches	P5	18/A7/M	5/17/M	49/6-14/R
Avg. total precipitation in Oct. in inches	P6	8/A10/M	5/18/M	49/6-14/R
Avg. total number of days with precipitation > 0.1" in Jan.	P7	23/L1/M	34/*/R	49/6-14/R
Avg. total number of days with precipitation ≥ 0.1" pct. in April	P8	23/L4/M	34/*/R	49/6-14/M
Avg. total number of days with precipitation ≥ 0.1" pct. in July	P9	23/L7/M	35/*/R	49/6-14/R
Avg. total number of days with precipitation ≥ 0.1" pct. in Oct.	P10	23/L10/M	34/*/R	49/6-14/R
Avg. annual total snowfall in inches	P11	17/17/M	5/30/M	49/6-14/R
Avg. total snowfall in Jan. in inches	P12	20/C1/M	34/*/R	49/6-14/R
Avg. total snowfall in April in inches	P13	21/C4/M	34/*/R	49/6-14/R
Avg. total snowfall in Nov. in inches	P14	20/C11/M	34/*/R	49/6-14/R

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SOLAR RADIATION				
Potential solar radiation Jan.	R2	12/*/M	12/*/M	12/*/M
Potential solar radiation April	R3	12/*/M	12/*/M	12/*/M
Potential solar radiation July	R4	12/*/M	12/*/M	12/*/M
Potential solar radiation Oct.	R5	12/*/M	12/*/M	12/*/M
Mean monthly pct. possible sunshine Jan.	R6	36/22/M	6/97/M	6/99/M
Potential solar radiation - annual, 1000's of Langleys	R11	12/*/M	12/*/M	12/*/M
Mean annual total hours of sunshine	R8	36/25/M	6/102/M	6/101/M
Mean annual number of clear days, sunrise to sunset	R9	6/110/M	6/101/M	6/61/M
Mean annual pan evaporation (inches)	R10	6/97/M	6/110/M	6/97/M

[1]Reference code 19/B1/M: 19=reference number (Michigan Department of Agriculture 1974); B1=page no. (*=no page number); and M=iso bar or R=raw data.

Appendix B.—Median values for all variables (rows) across all homoclimes and the Lake States regional average

TEMPERATURE							
Variable	Variable code	Homoclime number					
		13	10	5	18	20	9
Avg. temp. Jan.	T1	4	3	7	12	13	8
Avg. temp. Apr.	T2	37	39	39	40	39	42
Avg. temp. July	T3	66	68	67	66	65	70
Avg. temp. Oct.	T4	42	44	44	46	46	46
Avg. min. temp. Jan.	T5	-6	-7	-2	1	3	-3
Avg. min. temp. April	T6	26	28	26	28	27	30
Avg. min. temp. July	T7	52	55	55	54	52	58
Avg. min. temp. Oct.	T8	32	32	33	34	35	34
Avg. max. temp. Jan.	T9	15	14	18	23	22	18
Avg. max. temp. April	T10	49	50	51	52	52	53
Avg. max. temp. July	T11	78	80	80	79	79	83
Avg. max. temp. Oct.	T12	53	55	55	57	57	57
No. of days temp. ⩾ 90°F in July	T15	0	2	0	1	1	3
No. of days temp ⩽ 32°F in April	T18	22	22	22	19	21	19
No. of days temp ⩽ 32°F in Oct.	T20	17	16	15	14	14	13
Days since Jan. 1 to last day of 32°F or lower in spring	T22	150	150	150	148	155	143
Days since Jan. 1 to first day of 32°F or lower in fall	T23	262	262	262	260	258	267
Heating degree days, 65°F Base	T24	10,500	9,500	9,500	9,200	9,200	9,500
Runs of ⩾ 5 days with max. temp. > 30°F Jan. 24-30	T25	10	10	15	15	15	15
Runs of ⩾ 5 days with ⩽ 50°F Sept. 20-26	T36						
Runs of ⩾ 5 days with max. temp. < 30°F March 1-7	T26	40	40	40	45	45	40
Runs of ⩾ 5 days with max. temp. > 30°F Dec. 27-Jan. 2	T27	10	10	20	17	15	30
Runs of ⩾ 5 days with max. temp. > 50°F March 22-28	T28	10	10	15	15	10	20

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Runs of ⩾ 5 days with max. temp. > 50°F Nov. 8-14	T29	10	10	10	10	10	15
Runs of ⩾ 5 days with max. temp. > 90°F July 19-25	T30	10	10	10	5	5	15
Runs of ⩾ 5 days with min. temp. ⩽ 0°F Jan. 10-16	T31	60	60	40	30	25	40
Runs of ⩾ 5 days with min. temp. ⩽ 0°F Feb. 21-27	T32	20	20	20	11	12	20
Runs of ⩾ 5 days with min. temp. ⩽ 40°F April 26-May 2	T33	60	60	60	60	65	50
Runs of ⩾ 5 days with min. temp. ⩽ 40°F Oct. 4-10	T34	50	50	50	40	45	45
Runs of ⩾ 5 days with min. temp. ⩽ 50°F May 24-30	T35	60	60	60	55	65	50
PRECIPITATION							
Avg. annual total precipitation in inches	P1	26	20	26	31	33	24
Avg. annual total number of days precipitation > 0.1"	P2	135	115	135	125	150	105
Avg. total precipitation in Jan.	P3	0.8	0.6	0.8	1.1	1.5	0.7
Avg. total precipitation in April	P4	1.8	1.5	2.1	2.5	2.5	2.2
Avg. total precipitation in July	P5	3.5	3.1	3.6	4.0	3.7	3.2
Avg. total precipitation in Oct.	P6	1.7	1.3	1.8	2.1	2.2	1.5
Avg. total number of days with precipitation > 0.1" in Jan.	P7	3	3	3	3	6	2
Avg. total number of days with precipitation ⩾ 0.1" pct. in April	P8	5	3	4	6	6	5
Avg. total number of days with precipitation ⩾ 0.1" pct. in July	P9	7	6	7	7	7	6
Avg. total number of days with precipitation ⩾ 0.1" pct. in Oct.	P10	5	4	4	5	6	3
Avg. annual total snowfall in inches	P11	55	40	55	54	110	45
Avg. total snowfall in Jan.	P12	11	8	10	11	22	7
Avg. total snowfall in April	P13	6.0	3.0	5.0	4.4	7.5	4.0
Avg. total snowfall in Nov.	P14	8.0	7.0	8.0	8.0	21.0	6.0
SOLAR RADIATION							
Potential solar radiation Jan.	R2	53	52	56	60	59	60
Potential solar radiation April	R3	221	220	223	225	224	225
Potential solar radiation July	R4	299	299	300	300	300	300
Potential solar radiation Oct.	R5	118	117	121	125	124	125
Mean monthly pct. possible sunshine, Jan.	R6	45	45	45	40	35	45
Potential solar radiation - annual	R11	206	205	208	212	210	212
Mean annual total hours of sunshine	R8	2,500	2,500	2,500	2,300	2,200	2,500
Mean annual number of clear days, sunrise to sunset	R9	75	95	75	75	75	95
Mean annual pan evaporation (inches)	R10	30	35	30	32	32	40

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TEMPERATURE

Variable	Variable code	Homoclime number					
		11	12	4	7	3	14
Avg. temp. Jan.	T1	17	15	12	18	11	17
Avg. temp. Apr.	T2	39	39	42	41	44	44
Avg. temp. July	T3	65	64	70	66	72	70
Avg. temp. Oct.	T4	47	47	47	48	49	49
Avg. min. temp. Jan.	T5	8	8	3	9	1	8
Avg. min. temp. April	T6	29	29	31	29	32	32
Avg. min. temp. July	T7	53	53	57	53	60	58
Avg. min. temp. Oct.	T8	38	37	36	37	36	37
Avg. max. temp. Jan.	T9	24	22	23	26	21	26
Avg. max. temp. April	T10	49	49	54	53	55	55
Avg. max. temp. July	T11	76	76	82	80	84	82
Avg. max. temp. Oct.	T12	56	56	58	59	60	60
No. of days temp. ⩾ 90°F in July	T15	1	1	2	2	4	
No. of days temp ⩽ 32°F in April	T18	20	20	16	17	15	14
No. of days temp ⩽ 32°F in Oct.	T20	8	8	11	11	11	10
Days since Jan. 1 to last day of 32°F or lower in spring	T22	145	145	137	156	133	130
Days since Jan. 1 to first day of 32°F or lower in fall	T23	268	278	271	258	272	271
Heating degree days, 65°F Base	T24	8,700	8,800	8,700	8,200	8,500	8,200
Runs of ⩾ 5 days with max. temp. > 30°F Jan. 24-30	T25	15	15	15	25	15	25
Runs of ⩾ 5 days with min. temp. ⩽ 50°F Sept. 20-26	T36						
Runs of ⩾ 5 days with max. temp. > 30°F March 1-7	T26	45	45	50	55	50	55
Runs of ⩾ 5 days with max. temp. > 30°F Dec. 27-Jan. 2	T27	30	15	25	45	40	40
Runs of ⩾ 5 days with max. temp. > 50°F March 22-28	T28	10	10	15	17	30	17
Runs of ⩾ 5 days with max. temp. > 50°F Nov. 8-14	T29	10	7	15	12	20	15
Runs of ⩾ 5 days with max. temp. > 90°F July 19-25	T30	5	5	5	5	20	7
Runs of ⩾ 5 days with min. temp. ⩽ 0°F Jan. 10-16	T31	7	25	25	5	30	15
Runs of ⩾ 5 days with min. temp. ⩽ 0°F Feb. 21-27	T32	7	16	10	5	10	5
Runs of ⩾ 5 days with min. temp. ⩽ 40°F April 26-May 2	T33	60	65	55	50	40	50
Runs of ⩾ 5 days with min. temp. ⩽ 40° F Oct. 4-10	T34	35	45	30	25	40	25
Runs of ⩾ 5 days with min. temp. ⩽ 50°F May 24-30	T35	65	65	45	65	40	50

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(Appendix B continued)

PRECIPITATION							
Avg. annual total precipitation in inches	P1	31	32	29	31	25	29
Avg. annual total number of days precipitation > 0.1"	P2	150	150	115	145	105	115
Avg. total precipitation in Jan.	P3	1.5	2.5	1.0	1.5	0.7	1.2
Avg. total precipitation in April	P4	2.5	2.5	2.4	2.5	2.2	2.6
Avg. total precipitation in July	P5	2.7	2.7	3.5	3.0	3.1	3.0
Avg. total precipitation in Oct.	P6	2.7	2.5	1.9	2.2	1.6	2.2
Avg. total number of days with precipitation > 0.1" in Jan.	P7	6	9	2	5	1	2
Avg. total number of days with precipitation ⩾ 0.1" percent in April	P8	6	6	5	6	5	6
Avg. total number of days with precipitation ⩾ 0.1" percent in July	P9	6	6	7	6	5	6
Avg. total number of days with precipitation ⩾ 0.1" percent in Oct.	P10	7	6	5	6	4	5
Avg. annual total snowfall in inches	P11	95	135	46	75	40	45
Avg. total snowfall in Jan.	P12	24	35	10	21	7	10
Avg. total snowfall in April	P13	3.5	6.7	3.0	4.0	3.0	1.9
Avg. total snowfall in Nov.	P14	15.0	21.0	5.5	10.0	5.0	4.5
SOLAR RADIATION							
Potential solar radiation Jan.	R2	59	57	64	66	65	68
Potential solar radiation April	R3	224	223	228	228	228	230
Potential solar radiation July	R4	300	300	301	301	301	302
Potential solar radiation Oct.	R5	124	122	129	131	130	133
Mean monthly percent possible sunshine Jan.	R6	35	35	45	25	55	45
Potential solar radiation - annual	R11	211	209	215	216	216	218
Mean annual total hours of sunshine	R8	2,100	2,100	2,400	2,200	2,500	2,400
Mean annual number of clear days, sunrise to sunset	R9	75	75	85	75	95	85
Mean annual pan evaporation (inches)	R10	32	31	37	32	40	37

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(Appendix B continued)

TEMPERATURE

Variable	Variable code	Homoclime number 6	15	2	8	17	1
Avg. temp. Jan.	T1	20	14	21	14	21	23
Avg. temp. Apr.	T2	43	45	44	46	46	47
Avg. temp. July	T3	68	73	69	74	71	71
Avg. temp. Oct.	T4	49	50	50	51	51	52
Avg. min. temp. Jan.	T5	13	4	15	5	13	16
Avg. min. temp. April	T6	31	34	34	35	35	36
Avg. min. temp. July	T7	55	61	57	61	59	60
Avg. min. temp. Oct.	T8	39	38	41	39	40	41
Avg. max. temp. Jan.	T9	29	24	29	24	29	31
Avg. max. temp. April	T10	53	56	56	57	57	58
Avg. max. temp. July	T11	80	85	82	86	83	82
Avg. max. temp. Oct.	T12	59	62	61	63	62	63
No. of days temp. ≥ 90°F in July	T15	3	6	2	7	4	5
No. of days temp. ≤ 32°F in April	T18	15	13	13	13	12	10
No. of days temp. ≤ 32°F in Oct.	T20	8	10	7	10	7	6
Days since Jan. 1 to last day of 32°F Or lower in spring	T22	145	130	135	130	127	125
Days since Jan. 1 to first day of 32°F or lower in fall	T23	268	277	278	277	278	278
Heating degree days, 65°F Base	T24	7,700	8,000	7,200	7,500	7,200	6,700
Runs of ≥ 5 days with max. temp. > 30°F Jan. 24-30	T25	30	20	35	20	35	35
Runs of ≥ 5 days with min. temp. ≤ 50°F Sept. 20-26	T36						
Runs of ≥ 5 days with max. temp. > 30°F March 1-7	T26	60	60	70	60	70	82
Runs of ≥ 5 days with max. temp. 30°F Dec. 27-Jan. 2	T27	45	45	50	50	55	55
Runs of ≥ 5 days with max. temp. > 50°F March 22-28	T28	17	30	17	35	20	35
Runs of ≥ 5 days with max. temp. > 50°F Nov. 8-14	T29	15	20	17	30	17	25
Runs of ≥ 5 days with max. temp. > 90°F July 19-25	T30	7	30	7	30	10	10
Runs of ≥ 5 days with min. temp. ≤ 0°F Jan. 10-16 T31	5	25	5	20	10	5	
Runs of ≥ 5 days with min. temp. ≤ 0°F Feb. 21-27	T32	5	5	5	5	5	5
Runs of ≥ 5 days with min. temp. ≤ 40°F April 26-May 2	T33	47	40	45	30	45	42
Runs of ≥ 5 days with min. temp. ≤ 40°F Oct. 4-10	T34	25	25	17	20	17	17
Runs of ≥ 5 days with min. temp. ≤ 50°F May 24-30	T35	55	30	52	20	40	35

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(Appendix B continued)

PRECIPITATION							
Avg. annual total precipitation in inches	P1	31	28	31	28	30	33
Avg. annual total number of day precipitation > 0.1"	P2	145	105	145	105	120	145
Avg. total precipitation in Jan.	P3	1.5	0.8	2.0	0.7	1.4	2.0
Avg. total precipitation in April	P4	3.0	2.2	3.0	2.1	2.7	3.2
Avg. total precipitation in July	P5	2.7	3.5	2.7	3.2	3.0	3.0
Avg. total precipitation in Oct.	P6	2.7	1.6	2.7	1.6	2.2	2.7
Avg. total number of days with precipitation > 0.1" in Jan.	P7	6	1	6	1	3	6
Avg. total number of days with precipitation ⩾ 0.1" percent in April	P8	7	5	7	4	7	7
Avg. total number of days with precipitation ⩾ 0.1" percent in July	P9	5	6	6	6	6	5
Avg. total number of days with precipitation ⩾ 0.1" percent in Oct.	P10	6	4	6	4	5	6
Avg. annual total snowfall in inches	P11	75	40	65	40	40	45
Avg. total snowfall in Jan.	P12	25	7	22	7	10	13
Avg. total snowfall in April	P13	3.2	2.0	1.5	2.0	1.5	1.5
Avg. total snowfall in Nov.	P14	10.0	5.0	6.0	5.0	3.5	6.0
SOLAR RADIATION							
Potential solar radiation Jan.	R2	68	69	71	71	73	77
Potential solar radiation April	R3	230	231	232	232	233	235
Potential solar radiation July	R4	302	302	302	302	303	303
Potential solar radiation Oct.	R5	133	134	136	136	138	141
Mean monthly percent possible sunshine, Jan.	R6	25	55	25	55	45	35
Potential solar radiation - annual	R11	218	219	221	221	222	225
Mean annual total hours of sunshine	R8	2,300	2,500	2,400	2,700	2,400	2,400
Mean annual number of clear days, sunrise to sunset	R9	85	95	85	115	85	85
Mean annual pan evaporation (inches)	R10	33	45	37	45	37	37

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TEMPERATURE

Variable	Variable code	Homoclime number 19	16	Lake States regional average
Avg. temp. Jan.	T1	23	24	14
Avg. temp. Apr.	T2	47	48	43
Avg. temp. July	T3	72	72	70
Avg. temp. Oct.	T4	52	53	48
Avg. min. temp. Jan.	T5	15	17	4
Avg. min. temp. April	T6	36	37	31
Avg. min. temp. July	T7	61	61	58
Avg. min. temp. Oct.	T8	41	43	37
Avg. max. temp. Jan.	T9	30	32	24
Avg. max. temp. April	T10	58	59	54
Avg. max. temp. July	T11	83	84	82
Avg. max. temp. Oct.	T12	64	64	59
No. of days temp. ⩾ 90°F in July	T15	6	6	3
No. of days temp. ⩽ 32°F in April	T18	9	9	16
No. of days temp. ⩽ 32°F in Oct.	T20	5	3	11
Days since Jan. 1 to last day of 32°F or lower in spring	T22	125	125	135
Days since Jan. 1 to first day of 32°F or lower in fall	T23	281	288	271
Heating degree days, 65°F Base	T24	6,700	6,200	8,500
Runs of ⩾ 5 days with max. temp. >30°F Jan. 24-30	T25	35	40	20
Runs of ⩾ 5 days with min. temp. ⩽ 50°F Sept. 20-26	T36			
Runs of ⩾ 5 days with max. temp. <30°F March 1-7	T26	80	85	50
Runs of ⩾ 5 days with max. temp. > 30°F Dec. 27-Jan. 2	T27	60	65	35
Runs of ⩾ 5 days with max. temp. > 50°F March 22-28	T28	30	40	17
Runs of ⩾ 5 days with max. temp. > 50°F Nov. 8-14	T29	30	35	15
Runs of ⩾ 5 days with max. temp. > 90°F July 19-25	T30	15	15	10
Runs of ⩾ 5 days with min. temp. ⩽ 0°F Jan. 10-16	T31	5	5	20
Runs of ⩾ 5 days with min. Temp. ⩽ 0°F Feb. 21-27	T32	5	5	7
Runs of ⩾ 5 days with min. temp. ⩽ 40°F April 26-May 2	T33	35	35	50
Runs of ⩾ 5 days with min. temp. ⩽ 40°F Oct. 4-10	T34	15	15	30
Runs of ⩾5 days with min. temp. ⩽ 50°F May 24-30	T35	35	30	50

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(Appendix B continued)

	PRECIPITATION			
Avg. annual total precipitation in inches	P1	32	35	29
Avg. annual total number of days precipitation > 0.1″	P2	145	145	115
Avg. total precipitation in Jan.	P3	1.5	2.5	1.0
Avg. total precipitation in April	P4	3.2	3.7	2.5
Avg. total precipitation in July	P5	3.5	3.2	3.2
Avg. total precipitation in Oct.	P6	2.4	3.2	2.0
Avg. total number of days with precipitation > 0.1″ in Jan.	P7	4	6	3
Avg. total number of days with precipitation ⩾ 0.1″ percent in April	P8	7	7	5
Avg. total number of days with precipitation ⩾ 0.1″ percent in July	P9	6	6	6
Avg. total number of days with precipitation ⩾ 0.1″ percent in October	P10	5	6	5
Avg. annual total snowfall in inches	P11	35	45	45
Avg. total snowfall in Jan.	P12	9	13	10
Avg. total snowfall in April	P13	1.2	1.5	3.0
Avg. total snowfall in Nov.	P14	3.0	6.0	6.0
	SOLAR RADIATION			
Potential solar radiation Jan.	R2	77	80	65
Potential solar radiation April	R3	235	236	228
Potential solar radiation July	R4	303	304	301
Potential solar radiation Oct.	R5	141	144	130
Mean monthly percent possible sunshine, Jan.	R6	35	35	45
Potential solar radiation - annual	R11	225	227	216
Mean annual total hours of sunshine	R8	2,500	2,500	2,500
Mean annual number of clear days, sunrise to sunset	R9	85	85	85
Mean annual pan evaporation (inches)	R10	42	40	37

APPENDIX C

This appendix contains a detailed profile of each homoclime. Section I displays the relation between a given homoclimatic zone and all others. Zones at the left margin of the profile plot are highly similar to the zone under discussion using euclidean distances obtained from the cluster analysis as the metric. Highly similar zones have similar euclidean distances with the zone under discussion; highly dissimilar zones are further away in euclidean space.

Section II presents the minimum, median, and maximum values and the standard deviation and coefficient of variation for key explanatory variables. The Lake States medium values for the key explanatory variables are also given for comparison. The key explanatory variables are as follows:

T5 = average minimum January temperature, °F;
T11= average maximum July temperature, °F;
P12= average total snowfall in January, inches;
P13= average total snowfall in April, inches;
P14= average total snowfall in November, inches;
P5 = average total precipitation in July, inches;
P3 = average total precipitation in January, inches;
P1 = average annual total precipitation, inches;
R11= potential, extraterrestrial, normal radiation, 1,000 langleys;
R10= mean annual pan evaporation, inches; and
R6 = mean monthly percent possible sunshine, January.

HOMOCLIME 1

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	01.19.17. . . .16. . .02. .	06.14.15.07.03 08.	04.11. . 12.18 . . . 09.	20.05. .10.13	91
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

	Min	Median	Max	S.D.	C.V.	Region Median
Temperature (°F)						
Avg. Min. Jan (T5)	15	16	19	1.3	7	4
Avg. Max. Jul (T11)	79	82	84	1.3	1	82
(T11 -T5)	--	66	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	9	13	23	4.6	30	10
Apr (P13)	0.5	1.5	2.5	0.5	30	3
Nov (P14)	3	6	10	2.0	30	6
Avg. Total PPT:						
Jul (P5)	2.7	3	3.7	0.3	11	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	8	--	--	--	--
Jan [(P3/P1).100)]	--	6	--	--	--	--
Radiation						
Radiation (R11)(*)	223	225	228	1.5	1	216
Evaporation (R10)(in.)	32	37	42	3.0	7	37
Percent Sunshine Jan (R6)	30	35	35	1.0	3	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 2

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	02.06.17.01.14	07.15. .03.11 .19 . .16. .08 . .04.	.12.18. 20. . .09.	05. . .10.13	74
	Highly Similar <----------------------------			-> Highly Dissimilar	

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	13	15	17	1.5	10	4
Avg. Max. Jul (T11)	80	82	84	1.4	1.8	82
(T11 -T5)	--	67	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	11	22	28	5.7	28	10
Apr (P13)	1.5	1.5	2.5	.27	17	3
Nov (P14)	4	6	8	.99	15	6
Avg. Total PPT:						
Jul (P5)	2.5	2.7	3.5	0.3	10	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	8.9	--	--	--	--
Jan [(P3/P1).100)]	--	6.3	--	--	--	--
Radiation						
Radiation (R11)(*)	218	221	222	1.3	.6	216
Evaporation (R10)(in.)	35	37	38	1.2	3.2	37
Percent Sunshine Jan (R6)	25	25	35	2.9	11	45

*Radiation is measured in 1,000's of Langleys, i.e.,
223 = 223,000 Langleys

HOMOCLIME 3

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	03.15. .04. . . .14. . .02. .	09.07.06.11.17 .08. . .18	02. .05. 20.12 . . . 10.19 01	. . .13.16	59
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-5	1	4.5	1.9	206	4
Avg. Max. Jul (T11)	82	84.5	87	1.0	1.2	82
(T11 -T5)	--	83.5	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	7	9	0.8	10	10
Apr (P13)	1.7	3	5	.79	26	3
Nov (P14)	4	5	6	.64	12	6
Avg. Total PPT:						
Jul (P5)	2.8	3.1	4	.22	7.1	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	12	--	--	--	--
Jan [(P3/P1).100)]	--	3	--	--	--	--
Radiation						
Radiation (R11)(*)	213	216	217	1.1	.54	216
Evaporation (R10)(in.)	37	40	45	2.6	6.2	37
Percent Sunshine Jan (R6)	45	55	55	4.2	8.0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 4

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	04. .14.11.18	15. .05.12.02	08. . . 13.	01. . . .16	91
	. .03.09	06. .20. .	17. . . .	19. . . .	
	. .07. .	. . . . .	10. . . .	. . . . .	

Highly Similar <------------------------------> Highly Dissimilar

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-5	3	12	2.9	88	4
Avg. Max. Jul (T11)	76	82	85	2.0	2.5	82
(T11 -T5)	--	79	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	10	14	2.3	23	10
Apr (P13)	0.5	3	6	0.8	26	3
Nov (P14)	2 5	5.5	9	1.1	21	6
Avg. Total PPT:						
Jul (P5)	2.5	3.5	5.5	.6	16	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	11.9	--	--	--	--
Jan [(P3/P1).100)]	--	3.4	--	--	--	--
Radiation						
Radiation (R11)(*)	209	215	222	1.7	.8	216
Evaporation (R10)(in.)	33	37	40	2.7	7.5	37
Percent Sunshine Jan (R6)	25	45	55	2.8	6.4	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 5

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	05.18.13.09.11 .10.20.	04. .07.14. 12. .03.	06. .02. 08.17 15.	.01.19. .16	91
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-6	-2.5	6	2.7	-107	4
Avg. Max. Jul (T11)	69	80	87	2.9	3.7	82
(T11 -T5)	--	82	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	7	10	13	1.4	14	10
Apr (P13)	3	5	8	1.3	27	3
Nov (P14)	4	8	8	.52	12	6
Avg. Total PPT:						
Jul (P5)	2.8	3.6	4.5	.17	8.2	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	14	--	--	--	--
Jan [(P3/P1).100)]	--	3.4	--	--	--	--
Radiation						
Radiation (R11)(*)	207	208	212	1.3	.64	216
Evaporation (R10)(in.)	30	30	35	2.4	7.5	37
Percent Sunshine Jan (R6)	35	45	45	1.3	2.9	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 6

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	06.14.02. . . .07.	17.15.03.08. 04.11.01.	12.18.20. 16.05 19.09.	. . .10.13	63
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	11	13	16	1.4	11	4
Avg. Max. Jul (T11)	80	80	82	.5	.6	82
(T11 -T5)	--	67	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	11	25	31	5.9	25	10
Apr (P13)	1.5	3.2	4	1.1	37	3
Nov (P14)	4	10	15	3.1	31	6
Avg. Total PPT:						
Jul (P5)	2.7	2.7	3.3	.2	5.3	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	9.0	--	--	--	--
Jan [(P3/P1).100)]	--	4.8	--	--	--	--
Radiation						
Radiation (R11)(*)	215	218	221	1.9	.9	216
Evaporation (R10)(in.)	30	33	38	2.5	7.3	37
Percent Sunshine Jan (R6)	25	25	25	0	0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 7

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	07. .11.04.	.02. .15.09	17.05.08. .01	10.19.13. .16	57
	. .14.	.03. .20.	. . . .	. . . . .	
	. .06. .	.18 . . .	. . . .	. . . . .	
		.12			

Highly Similar <-----------------------------> Highly Dissimilar

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	7.5	9	11.5	1.0	11	4
Avg. Max. Jul (T11)	76	80	82	1.5	2.0	82
(T11 -T5)	--	71	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	18	21	35	4.7	21	10
Apr (P13)	2.5	4	5	0.6	15	3
Nov (P14)	6	10	20	0.9	36	6
Avg. Total PPT:						
Jul (P5)	2.3	3	4	0.4	14	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	9.7	--	--	--	--
Jan [(P3/P1).100)]	--	4.8	--	--	--	--
Radiation						
Radiation (R11)(*)	212	216	218	1.8	0.8	216
Evaporation (R10)(in.)	33	32	38	1.6	4.6	37
Percent Sunshine Jan (R6)	25	25	35	2.0	7.6	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 8

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	08.15. .17.19	03.02. .04.07 14.01. . .16 .06	.09.11. .18	12.20.10. .13 .05.	77
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-6	5	7.5	3.6	92	4
Avg. Max. Jul (T11)	84	86	87	.8	.9	82
(T11 -T5)	--	81	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	5	7	9	.89	13	10
Apr (P13)	2	2	3	.36	17	3
Nov (P14)	4	5	6	.52	10	6
Avg. Total PPT:						
Jul (P5)	2.8	3.2	3.8	.28	8.9	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	12	--	--	--	--
Jan [(P3/P1).100)]	--	2.7	--	--	--	--
Radiation						
Radiation (R11)(*)	219	221	222	.9	.4	216
Evaporation (R10)(in.)	45	45	50	2.5	5.3	37
Percent Sunshine Jan (R6)	55	55	55	0	0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 9

I. PROFILE PLOT

```
MIN.                                                                 MAXIMUM
VALUE               HOMOCLIMES RELATIVE TO EACH OTHER                VALUE

 10 | 09.  .  .04.10 | 11.20.13.12.06 | 08.  .02.   .  | .01.  .  .16 |   78
    |  .   .  .18.   |   .07.15.  .   |  .   .17.   .  | .19.  .  .   |
    |  .   .  .05.   |   .14 .  .  .  |  .   .   .  .  |  .  .  .  .  |
    |                |   .03                                          |
    | Highly Similar <------------------------------> Highly Dissimilar |
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II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-8	-3	--	1.8	-66	4
Avg. Max. Jul (T11)	80	83	85	1.2	1.5	82
(T11 -T5)	--	86	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	7	11	1.4	19	10
Apr (P13)	1	4	5	1.0	28	3
Nov (P14)	4	6	8	0.9	15	6
Avg. Total PPT:						
Jul (P5)	2.1	3.2	4	0.3	10	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	13	--	--	--	--
Jan [(P3/P1).100)]	--	3	--	--	--	--
Radiation						
Radiation (R11)(*)	208	212	214	1.7	0.8	216
Evaporation (R10)(in.)	35	40	40	2.5	6.5	37
Percent Sunshine Jan (R6)	45	45	55	2.5	5.4	45

*Radiation is measured in 1,000's of Langleys, i.e.,
223 = 223,000 Langleys

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	10.05.13.09.18	20.04.11.03.14	15.06. .08 .17	. .01. .16	98
	. . . .	. . .12.	. . . .	. .19. .	
	. . . .	. . .07.	. . . . .	. . . .	

Highly Similar <-----------------------------> Highly Dissimilar

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-8	-7	-.8	1.4	-21	4
Avg. Max. Jul (T11)	80	80	83	1.0	1.3	82
(T11 -T5)	--	87	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	8	10	.9	12	10
Apr (P13)	1	3	4	1.0	40	3
Nov (P14)	5	7	8	.85	12	6
Avg. Total PPT:						
Jul (P5)	2.9	3.1	3.5	.2	5.9	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	14.8	--	--	--	--
Jan [(P3/P1).100)]	--	2.9	--	--	--	--
Radiation						
Radiation (R11)(*)	203	205	208	1.6	.8	216
Evaporation (R10)(in.)	30	35	35	2.3	6.8	37
Percent Sunshine Jan (R6)	45	45	45	0	0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 11

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	11. .07.20. . .18.04. . .12. .	14.05.03. .02 06.09.	15. .17.08 . 10. . . . 13. . . .	01. .19. .16	69

Highly Similar <------------------------------> Highly Dissimilar

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	6	8	12	1.5	18	4
Avg. Max. Jul (T11)	75	76	79	1.0	1.2	82
(T11 -T5)	--	68	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	14	24	31	5.1	22	10
Apr (P13)	3	3.5	8	1.5	36	3
Nov (P14)	7	15	17	3.4	26	6
Avg. Total PPT:						
Jul (P5)	2.7	2.7	3.8	0.3	9.5	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	8.7	--	--	--	--
Jan [(P3/P1).100)]	--	4.8	--	--	--	--
Radiation						
Radiation (R11)(*)	209	211	213	1.0	0.5	216
Evaporation (R10)(in.)	27.5	32	37.5	2.3	7.2	37
Percent Sunshine Jan (R6)	25	35	45	6.3	19.3	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 12

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	12. .11.18. . .20. . . .12. .	07.05.04.06.13 . . .09. . . .14.	03. .15. .17 10. . . . 02. . . .	08.01. .19.16	78
	Highly Similar <------------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	4	8	11	2.1	27	4
Avg. Max. Jul (T11)	75	76	78	1.3	1.6	82
(T11 -T5)	--	68	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	30	35	45	6.1	17	10
Apr (P13)	5	6.7	7.5	1.1	17	3
Nov (P14)	16	21	22	2.5	13	6
Avg. Total PPT:						
Jul (P5)	2.7	2.7	3.3	.19	6.5	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	8.3	--	--	--	--
Jan [(P3/P1).100)]	--	7.6	--	--	--	--
Radiation						
Radiation (R11)(*)	207	209	211	1.4	.7	216
Evaporation (R10)(in.)	28	31	33	1.9	6.0	37
Percent Sunshine Jan (R6)	25	35	35	3.5	10	45

*Radiation is measured in 1,000's of Langleys, i.e.,
223 = 223,000 Langleys

HOMOCLIME 13

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	13. .10. .18 . .05. .20 . .12. .	09. .11. .07 . .12. .03 . .04. .	14.06.15. .02 . . . .08 02. . . .	17. .01.19.16	106
	Highly Similar <------------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-8	-6	2	2.9	-55	4
Avg. Max. Jul (T11)	69	78	81	3.8	4.9	82
(T11 -T5)	--	84	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	9	11	13	1.3	12	10
Apr (P13)	2	6	8	1.9	36	3
Nov (P14)	7	8	8	.4	4.9	6
Avg. Total PPT:						
Jul (P5)	2.8	3.5	3.5	0.2	5.9	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	13.5	--	--	--	--
Jan [(P3/P1).100)]	--	3.3	--	--	--	--
Radiation						
Radiation (R11)(*)	202	206	207	1.3	.6	216
Evaporation (R10)(in.)	30	30	30	0	0	37
Percent Sunshine Jan (R6)	45	45	45	0	0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 14

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	14.06.07.03. . .04.15.	02.17.08. .09 .11. . .18	.01.12. .05 . .20. .08 . .19. .	. .10. .13 . .16.	57
	Highly Similar <------------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	2.5	8	13	2.9	36	4
Avg. Max. Jul (T11)	78	82	85	1.8	2.2	82
(T11 -T5)	--	74	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	7.5	10	23	2.6	23	10
Apr (P13)	1.3	1.9	4	0.8	35	3
Nov (P14)	3	4.5	8	1.1	24	6
Avg. Total PPT:						
Jul (P5)	2.3	3	4	0.4	13.9	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	10.3	--	--	--	--
Jan [(P3/P1).100)]	--	4.5	--	--	--	--
Radiation						
Radiation (R11)(*)	214	218	221	1.4	0.6	216
Evaporation (R10)(in.)	33	37	43	2.7	7.4	37
Percent Sunshine Jan (R6)	25	45	45	8.8	22	4.5

*Radiation is measured in 1,000's of Langleys, i.e.,
223 = 223,000 Langleys

HOMOCLIME 15

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	15.08. .14. .03.	17.06.07. .09 04. .02. .19	01. .18. .16 11.	05.10. . .13 20. . . . 12. . . .	64
	Highly Similar <------------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-6	4	7.5	3.2	84	4
Avg. Max. Jul (T11)	83	85	87	.9	1.1	82
(T11 -T5)	--	81	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	5	7	11	1.3	18	10
Apr (P13)	1.3	2	4	.5	23	3
Nov (P14)	4	5	6.5	.7	13	6
Avg. Total PPT:						
Jul (P5)	2.8	3.5	4	.3	10	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	12.5	--	--	--	--
Jan [(P3/P1).100)]	--	2.9	--	--	--	--
Radiation						
Radiation (R11)(*)	217	219	222	1.6	.7	216
Evaporation (R10)(in.)	38	45	50	2.9	6.4	37
Percent Sunshine Jan (R6)	45	55	55	4.2	8	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 16

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	16. .01. .17 . .19.	02.08. .06.14 . . .15.	07. .04.11 .12 03. . . .09	18.20.05. .10 . . . .13	98
	Highly Similar <------------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	17	17	19	0.7	4.0	4
Avg. Max. Jul (T11)	82	84	85	1.0	1.7	82
(T11 -T5)	--	67	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	13	18	5.3	42	10
Apr (P13)	0.5	1.5	1.5	0.5	43	3
Nov (P14)	2	6	8	2.7	47	6
Avg. Total PPT:						
Jul (P5)	2.8	3.2	4	.30	9.9	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	9.4	--	--	--	--
Jan [(P3/P1).100)]	--	7.1	--	--	--	--
Radiation						
Radiation (R11)(*)	226	227	228	0.8	0.3	216
Evaporation (R10)(in.)	38	40	43	2.1	5.4	37
Percent Sunshine Jan (R6)	35	35	35	0	0	4.5

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 17

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	17. .01.08.06	.16.03.04.	11. .09.18 .12	20.05. .10.13	79
	. .02. .15	. .07. .	. . . .	. . . .	
	. .19. .14	. . . .	. . . .	. . . .	
	Highly Similar <-------------------------------			------> Highly Dissimilar	

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	6.5	13	17	2.8	23	4
Avg. Max. Jul (T11)	80	83	87	1.3	1.5	82
(T11 -T5)	--	70	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	8	10	18	1.6	16	10
Apr (P13)	.5	1.5	3	.5	41	3
Nov (P14)	2.5	3.5	7	.9	25	6
Avg. Total PPT:						
Jul (P5)	2.3	3	5	.6	18	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	9.8	--	--	--	--
Jan [(P3/P1).100)]	--	4.8	--	--	--	--
Radiation						
Radiation (R11)(*)	219	222	228	1.5	.6	216
Evaporation (R10)(in.)	33	37	43	2.4	6.1	37
Percent Sunshine Jan (R6)	25	45	45	6.5	17	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 18

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	18.20.11.09.07 .05. .12.10 . . .04.14	13 .14.03.06.	15.02. .17 . . . .08	.01.19. .16	81
	Highly Similar <----------------------------			--> Highly Dissimilar	

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	-1	1	9	1.9	101	4
Avg. Max. Jul (T11)	75	79	87	1.8	2.3	82
(T11 -T5)	--	78	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	7	11	20	2.5	21	10
Apr (P13)	2.9	4.4	7.5	.9	20	3
Nov (P14)	6	8	13	1.7	20	6
Avg. Total PPT:						
Jul (P5)	2.8	4	6	0.6	15	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	13	--	--	--	--
Jan [(P3/P1).100)]	--	3.5	--	--	--	--
Radiation						
Radiation (R11)(*)	208	212	214	1.4	.7	216
Evaporation (R10)(in.)	28	32	38	1.4	4.3	37
Percent Sunshine Jan (R6)	35	40	45	4.9	12.3	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 19

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	19.01.17. .08 . .16.	02 .15.14.03.07 .06.	04. .11.09	18.20. .10.13 12.05.	94
	Highly Similar <-----------------------------> Highly Dissimilar				

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	10	15	20	2.9	19	4
Avg. Max. Jul (T11)	82	83	87	1.4	1.7	82
(T11 -T5)	--	68	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	6	9	13	1.7	18	10
Apr (P13)	0.5	1.2	1.8	0.5	43	3
Nov (P14)	2	3	6	0.9	27	6
Avg. Total PPT:						
Jul (P5)	2.5	3.5	4.5	0.5	15	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	10.7	--	--	--	--
Jan [(P3/P1).100)]	--	4.6	--	--	--	--
Radiation						
Radiation (R11)(*)	223	225	228	1.3	0.6	216
Evaporation (R10)(in.)	33	42	43	2.7	6.7	37
Percent Sunshine Jan (R6)	35	35	45	5	12	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

HOMOCLIME 20

I. PROFILE PLOT

MIN. VALUE	HOMOCLIMES RELATIVE TO EACH OTHER				MAXIMUM VALUE
10	20.18.12. .	13 .10. .14.	.15. . .17	.01. .19.16	85
	. .11. .	07 . . .06.	.02. . .08	. . . .	
	. .05. .	04 . . .03.	. . . .	. . . .	
		09			

Highly Similar <----------------------------> Highly Dissimilar

II. KEY VARIABLE PROFILE

Temperature (°F)	Min	Median	Max	S.D.	C.V.	Region Median
Avg. Min. Jan (T5)	1.5	3	7	1.7	48	4
Avg. Max. Jul (T11)	77	79	81	1.2	1.5	82
(T11 -T5)	--	76	--	--	--	78
Precipitation (in.)						
Avg. Total snowfall:						
Jan (P12)	19	22	34	4.4	18	10
Apr (P13)	5	7.5	10	1.6	22	3
Nov (P14)	17	21	27	2.9	14	6
Avg. Total PPT:						
Jul (P5)	3	3.7	4	.31	8.8	3.2
Percent Total PPT In:						
Jul [(P5/P1).100)]	--	11.5	--	--	--	--
Jan [(P3/P1).100)]	--	4.5	--	--	--	--
Radiation						
Radiation (R11)(*)	210	210	211	0.5	0.2	216
Evaporation (R10)(in.)	33	32	33	0	0	37
Percent Sunshine Jan (R6)	35	35	35	0	0	45

*Radiation is measured in 1,000's of Langleys, i.e., 223 = 223,000 Langleys

APPENDIX D

Given a system described by N variables, the model upon which principal component analysis is based is given by equation 1.

$$Z_j = A_{j1} \cdot F_1 + A_{j2} \cdot F_2 + \ldots A_{jk} \cdot F_k \quad (1)$$

where:

Z_j = standard score of varible j;
A_{jk} = component coefficient;
F_k = component;
j = 1 to N; and
k = 1 to n.

It is hypothesized in equation 1 that every variable score equals a linear combination of imaginary components. A statistical package program such as SAS 79 (Helwig and Council 1979) can be used to generate a factor pattern matrix (table 4). The factor pattern matrix is equation 1 expanded for every variable Z_j across every component F_k where n, the number of components, is less than N, the number of variables. The elements A_{jk} represent the correlation of variable Z_j with component F_k (table 4).

The next step is to obtain the factor score matrix. The process is best illustrated in matrix notation. Using matrix notation, equation 1 can be written:

$$Z = A \cdot F \quad (2)$$

where:
Z = vector of variables;
A = matrix of component coefficients; and
F = vector of components.

Solving for F, the following steps for the general case can be used:

$$A' \cdot Z = A' \cdot A \cdot F \quad (3)$$
$$F = (A' \cdot A)^{-1} \cdot A' \cdot Z$$
Let $(A' \cdot A)^{-1} \cdot A' = Q$
then
$$F = Q \cdot Z \quad (4)$$

Table 4.—*Structure of a factor pattern matrix*

Variable	Component F^1	F^2	F^3	...	F^k
Z_1	A_{11} (.83)	A_{12} (.61)	A_{13} (.03)	...	A_{1k}
Z_2	A_{21} (.06)	A_{22} (.91)	A_{23} (.55)	...	A_{2k}
Z_3	A_{31} (.49)	A_{32} (.03)	A_{33} (.88)	...	A_{3k}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Z_j	A_{j1}	...	...	...	A_{jk}

Note: The A_{jk} members of the factor pattern matrix are correlation coefficients between variables Z_j and components F_k. The numbers in parenthesis are a numerical example. These numbers would come from a computer output of a principal component analysis. In matrix notation the above structure may be written as: Z = A • F.

Table 5.—*Structure of a factor score matrix*

Component	Variable Z_1	Z_2	Z_3	...	Z_j
F_1	Q_{11} (1.02)	Q_{12} (- .69)	Q_{13} (.40)	...	Q_{1j}
F_2	Q_{21} (.28)	Q_{22} (.93)	Q_{23} (-.59)	...	Q_{2j}
F_3	Q_{31} (-.58)	Q_{32} (.36)	Q_{33} (.93)	...	Q_{3j}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
F_k	Q_{k1}	...	...	...	Q_{kj}

Note: The numbers in parenthesis are derived from the numbers in table 4. In matrix notation the structure of table 4 can be written as:
Z = A • F. The Q's of this table are derived as follows:
inverse (A) • Z = inverse (A) • A • F
let inverse (A) = Q
Q • Z = F or
F = Q • Z

where:
A' = transpose of A;
$(A' \cdot A)^{-1}$ = inverse of $(A' \cdot A)$; and
Q = matrix of component scores.

By expanding equation 4 into algebraic notation, it can be seen that each factor score is a linear combination of all the variables in the system (table 5).

$$F_k = Q_{k1}Z_1 + Q_{k2}Z_2 + \ldots + Q_{kj}Z_j \quad (5)$$

where:
F_k = component scores
Q_k = component scoring coefficients;
Z_j = standard score of variables;
j = 1 to N, the number of variables; and
k = 1 to n, the number of components.

Finally, each observation can be scored across all components (table 6).

The data have now been converted from a matrix of scores for every observation across every variable to a matrix of scores for every observation across a number of components (table 6). In doing this we have reduced the dimensionality of the system without losing a significant amount of information.

Table 6.—*Structure of the matrix of observations scored across all components*

Observation	Component			
	F_1	F_2	F_3	... F_k
0_1	X_{11} (0.52)	X_{12} (0.84)	X_{13}(0.64)	... X_{ik}
0_2	X_{21} (1.35)	X_{22}(-2.32)	X_{23} (-0.44)	... X_{2k}
0_3	X_{31} (-1.42)	X_{32} (-0.44)	X_{33} (1.58)	... X_{3k}
.	.	.	.	. .
.	.	.	.	. .
.	.	.	.	. .
0_i	X_{il}	...	...	... X_{ik}

Note: The values for the X's are derived in the following manner. Given the field data in standard scores:

Observation	Z_1	Z_2	Z_3
0_1	1.21	.48	-.96
0_2	.68	-.20	.03
0_3	-.83	-1.20	1.65

$X_{11} = Q_{11} \cdot (Z_1 \text{ of } 0_1) + Q_{12} \cdot (Z_2 \text{ of } 0_1) + Q_{13} \cdot (Z_3 \text{ of } 0_1) = (1.02)(1.21) + (-.69)(.48) + (.40)(-.96) = 0.52$

$X_{23} = Q_{31} \cdot (Z_1 \text{ of } 0_2) + Q_{32} \cdot (Z_2 \text{ of } 0_2) + Q_{33} \cdot (Z_3 \text{ of } 0_2) = (-0.58)(.68) + (0.36)(-0.20) + (0.93)(0.03) = 0.44$, etc.

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Rauscher, H. Michael.

Homogeneous Macroclimatic Zones of the Lake States. Res. Pap. NC-240. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1984. 39 p.

The macroclimate of the Lake States is summarized and described by mapped homoclimatic zones. Cluster analysis in conjunction with principal components analysis were used to derive the homoclimatic zones. Each homoclimatic zone is qualitatively and quantitatively compared to all the others.

KEY WORDS: Classification, cluster analysis, principal components analysis.